M&V Strategies for a Cogen Plant at the GSA White Oak

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By
Mustafa Abbas

Sempra Energy Solutions

M&V Strategies for a Cogen Plant

PHASE 1 & 2

- Located at Silver Spring, MD
- Approx. Cost: $25M (Cogen Plant and Distribution)
- Approx. Annual Savings: $1.04M in Energy
  $1.8M in O&M
- Building-Side Savings: $0.4M
- Over 20 Years: >$100M in Total Savings

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Energy Conservation Measures (ECM)

- Photovoltaic System
- Phase 1 & 2 Cogeneration Plant
- Hydronic Distribution
- Site Electrical Distribution

- Lighting Upgrades
- Glazing Upgrades
- AHU Redesign
- ChW Pump VFDs
- HW Pump VFDs
- Economizer
- Demand Control Ventilation
- Night Setback

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COGEN PLANT (Phase 1&2)

Wartsile Engine:	6MW
Standby Diesel:	2MW
Absorption Chiller:	1 @ 1,130 Tons
Electric Chiller:	2 @ 1,980 Tons
Hot Water Boiler:	3 @ 10,000 MBtu/h
Heat Recovery Boiler:	1 @ 20,000 MBtu/h

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BASELINE

Basesd On;

- 35% Design Drawing for Office Building
- 100% Design Drawing for Laboratory
- 50% Design Drawing for Central Plant

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PLANT BASELINE

- No Cogen
- 25kW Photovoltaic Array
- 3 - 1,130 Ton Electric Chillers
- 3 - CV 100hp CHWPs
- 3 - CV 125hp CWPs
- 3 - CV 100hp CT Fans
- 12°F CHW DT; 12°F CW DT

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EXISTING PLANT (Phase 1 & 2)

- 6 - MW Cogen + 2MW Backup
- 28kW Photovoltaic Array
- 1 - 1,130 Ton Lead Absorption Chiller
- 2 - 1,980 Ton Electric Chillers
- 1 - 250hp CHWP with VFD
- 3 - 150hp CWPs with VFD
- 3 - 75hp CT Fans with VFD
- 20°F CHW DT; 17°F CW DT

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M&V APPROACH

1. M&V for Chillers

2. M&V For Engine

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M&V For Chillers

Point	Engineering Units	Interval
Chiller Command	On/Off	15 min.
Absorption Chiller H/W consmp.	GPM	15 min.
Absorption Chiller H/W Supply Temp.	^{o}F	15 min.
Absorption Chiller H/W Return Temp.	^{o}F	15 min.
Chiller Power	kW	15 min.
Chiller Flow (Electrical Chiller)	GPM	15 min.
Chiller Flow (Absorption Chiller)	GPM	15 min.
Chilled Water Supply Temp.	^{o}F	15 min.
Chilled Water Return Temp.	^{o}F	15 min.

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M&V For Chillers

- Calculate kW/Ton for Electric Chillers

  kW/Ton = (Chiller kW x (12,000)/(500 x GPM x ΔT).

- Calculate COP for Absorption Chiller

  COP = [500 x HW GPM x ΔT] / (500 x CHW GPM x ΔT]

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M&V For Chillers

1. Campus Thermal Load as Agreed-to From Simulation

2. Compare kW/Ton Profiles of Actual Performance vs Manufacturer's Specs.

3. A) If within agreed-to band, then Savings as Calculated

   B) If > band, then Savings Recalculated by substituting Actual Performance Profile with Agreed-to Load profile

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M&V For Cogen Engine

Point	**Engineering Units**	**Interval**
Generated electricity	kWh	15 min.
N. G. consumption by the engines	MMBtu	15 min. .

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M&V For Cogen Engine

- Calculate Heat Rate for the Engine

- Heat rate (Btu/kWh) is an indication of the performance of the engines. It is the ratio of the heat added to the cycle in Btu/h (LHV), to generation, in kWh

- Heat Rate = Gas Consumption [Btu(LHV)] / [(kWh Output at the shaft).

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M&V For Cogen Engine

1. Campus kW Load as Agreed-to From Simulation

2. Compare Heat Rate Profiles of Actual Performance vs Manufacturer’s Specs.

3. A) If within agreed-to band, then Savings as Calculated

   B) If > band, then Savings Recalculated by substituting Actual Performance Profile with Agreed-to Load profile

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BASELINE MODELING

Days	Hour	OADB (deg F)	Average Electric (kW)	Average Heating (btuh)	Average Cooling (ton)
			a = TRACE data	b = TRACE data	c = TRACE data
31	1	31	1457	15,264,900	250
	2	29	1457	15,771,443	237
	3	28	1457	16,225,414	222

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BASELINE MODELING

Electricity from Grid (kW)	Chiller Operation				Boiler Operation (btuh)
d = a + g + h + I	Chiller #4 (ton-hr)	Chiller #3 (ton-hr)	Chiller #2 (ton-hr)	Chiller #1 (ton-hr)	f = b* (1 + %DA steam) + loss
1831	273	0	0	0	17,070,690
1819	260	0	0	0	17,629,861
1806	245	0	0	0	18,130,998

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BASELINE MODELING

	kW	total kWh	On-pk	Mid-pk	Off-pk	on-pk all kwh	n-pk $/kW	Mid-pk $/kWh	off	$/KW	Elec $	Boiler Fuel Consumption (mmBTU)	Fuel $
Jan	4,217	1,833,527	741,909	627,722	463,896	0.02375	0.03265	0.02708	0.01438	4.069	$108,872	17,850	$71,399
Feb	4,204	1,656,455	669,329	567,259	419,867	0.02375	0.03265	0.02708	0.01438	4.069	$99,974	16,406	$65,626

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POST MODELING

Days	Hour	OADB (deg F)	Facility Electric (kW)	Heating w/ Pipe Losses (btuh)	Cooling w/ Pipe Losses (ton-hr)
			a = from TRACE runs	b = y + max(col. y)*1%	c = z + max(z) * 1%
31	1	31	1788	3,664,477	16
	2	29	1788	3,889,363	16
	3	28	1789	4,088,749	16

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POST MODELING

Total Electric Need (kW)	No. of Engines Required	Engine Load (%)	Net Elec output (kW)	Grid Electricity (kW)
d = a + o + p + q	e = roundup (d/engine capacity)	f = d / (e * engine capacity)	g = min(d, total # of engines installed * engine capacity)	h = d - g
2,015	1	34%	2,015	0
2,014	1	34%	2,014	0
2,013	1	34%	2,013	0

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POST MODELING

Fuel (HHV) input kbtu/hr	HR Boiler From Exhaust (kBTUh)	HT jacket (kBTUh)	LO jacket (kBTUh)	LT jacket (kBTUh)
i = f * slope1 + constant1 (from "Engine Performance" sheet)	j = f * slope2 + constant2 (from "HRSG Performance" sheet)	k = f * slope3 + constant3 (from "Engine Performance" sheet)	k1 = f * slope4 + constant1 (from "Engine Performance" sheet)	k2 = f * slope5 + constant1 (from "Engine Performance" sheet)
21,447	3,544	4,401	1,570	1,338
21,441	3,544	4,401	1,570	1,338
21,436	3,543	4,400	1,570	1,338

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POST MODELING

Boiler Operation (BTUh)	Boiler Natural Gas (mmBTUh)	(n4) Chiller #4 (ton-hr)	(n3) Chiller #3 (ton-hr)
l = b - j*1000 - k*1000-k1*1000	m = l/10^6/boiler eff	n4	n3
0	0	16	0
0	0	16	0
0	0	16	0

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POST MODELING

Month	Days/month	Peak Demand	On-Peak Daily Consumption	On-Peak Daily Consumption	Mid-Peak Daily Consumption	Off-Peak Daily Consumption	Total Daily Consumption
		(kW)	*(kWh)*	*(kWh)*	*(kWh)*	*(kWh)*	*(kWh)*
Jan	31	0	0	0	0	0	0
Feb	28	0	0	0	0	0	0
Mar	31	0	0	0	0	0	0

Monthly Peak Demand	Monthly On-Peak Consumption	Monthly Mid-Peak Consumption	Monthly Off-Peak Consumption	Total Monthly Consumption	Daily Fuel Consumption	Monthly Fuel Consumption
(kW)	*(kWh)*	*(kWh)*	*(kWh)*	*(kWh)*	*(mmBTU)*	*(mmBTU)*
0	0	0	0	0	677	20,979
0	0	0	0	0	685	19,174
0	0	0	0	0	651	20,181

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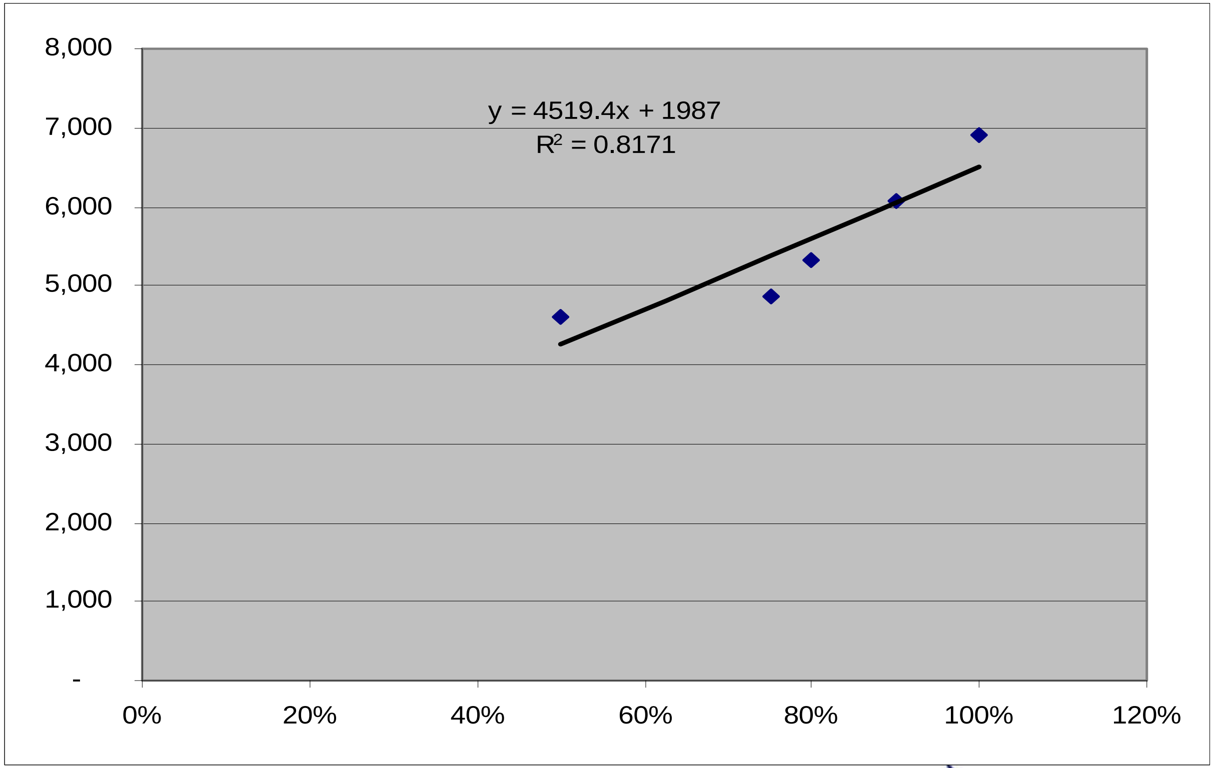
POST MODELING

Load	Steam Productio
50%	4,613
75%	4,856
80%	5,323
90%	6,082
100%	6,913



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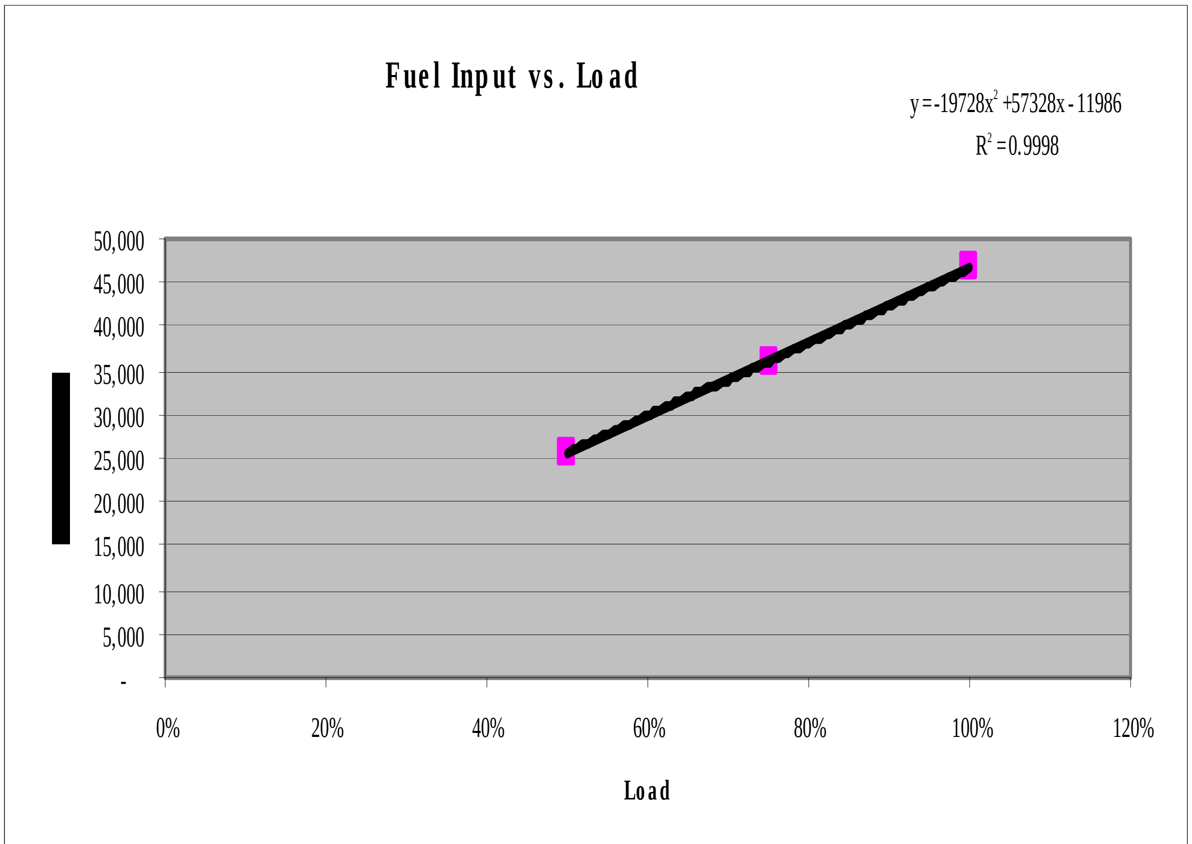
POST MODELING



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CONCLUSION

- Plant and the Buildings did not exist
- Base loads are simulated based on designs drawings
- Post loads are simulated based on value engineering modifications to the original design
- Savings are based on efficiency guarantee – not on loads
  - SES does not have control over buildings loads
  - SES has control over how system performs

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